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Publication date:
2017

Document Version
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

Citation (APA):
Eladl, A., Tosello, G., Mostafa, R., Soltan, H., & Hansen, H. N. (2017). *Investigation of process parameters influence on flash formation in injection moulding of polymer micro features through design of experiments*. Poster session presented at euspen's 17th International Conference & Exhibition, Hannover, Germany.

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Investigation of process parameters influence on flash formation in injection moulding of polymer micro features through design of experiments

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Abstract

Micro injection moulding is one of the key technologies for micro manufacture due to its mass-production capability and relatively low component cost. Flash defects are among the most critical issues in the replication of micro features and constitute a manufacturing constrain in applying injection moulding in a range of micro engineering applications. In the present research the effects of four processing parameters on the amount of flash on a micro finger test structure were investigated using two different polymer materials and applying DOE approach. In particular, the following process parameters were considered: injection speed, holding pressure, melt temperature and mould temperature. The study revealed that for the materials with lower viscosity the injection speed, followed by barrel temperature, are the most influential parameters for increasing the amount of flash. On the other hand, barrel temperature, injection velocity, and mould temperature resulted as the most influential parameters for increasing the flash amount when moulding with high viscosity materials. Conversely, the holding pressure did not have a clear effect on the flash amount.

Material, Method and equipment

Injection moulding experiments were carried out on an Arburg (Allrounder 370 A) injection moulding machine which has maximum clamping force 60 tons with screw diameter of 18 mm. A commercially available unfilled material polypropylene (PP, trade name 400-GA05), manufactured by INEOS Olefins polymers Europe and acrylonitrile butadiene styrene (ABS, trade name Terluran GR35) manufacturing by BASF were applied as the polymer materials in this study. The investigated parameters were: injection speed (V_i), holding pressure (P_h), melt temperature (T_b) and mould temperature (T_m). These parameters were considered as the factors affecting the capability of the microinjection moulding process. By considering the injection moulding machine capability and the materials properties different injection process setting were selected for the statistical design of experiments, see table 1.

Injection moulding process parameters	Low level (-)	Low level (+)
Injection speed	140 mm/s	220 mm/s
Holding pressure PP	10 MPa	60 MPa
Holding pressure ABS	20 MPa	70 MPa
Melt temperature	240 °C	270 °C
Mould temperature	20 °C	60 °C

The part is a rectangular shape (20mm*10mm*1.5mm) with four fingers. The four fingers have the same length of 15 mm, the same width of 3 mm and different thicknesses 0.7 mm, 0.5 mm, 0.3 mm and 0.1 mm. see figure 1

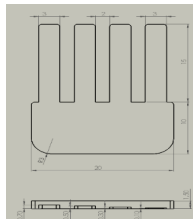


Fig 1: Micro fingers test structure geometry and moulded part

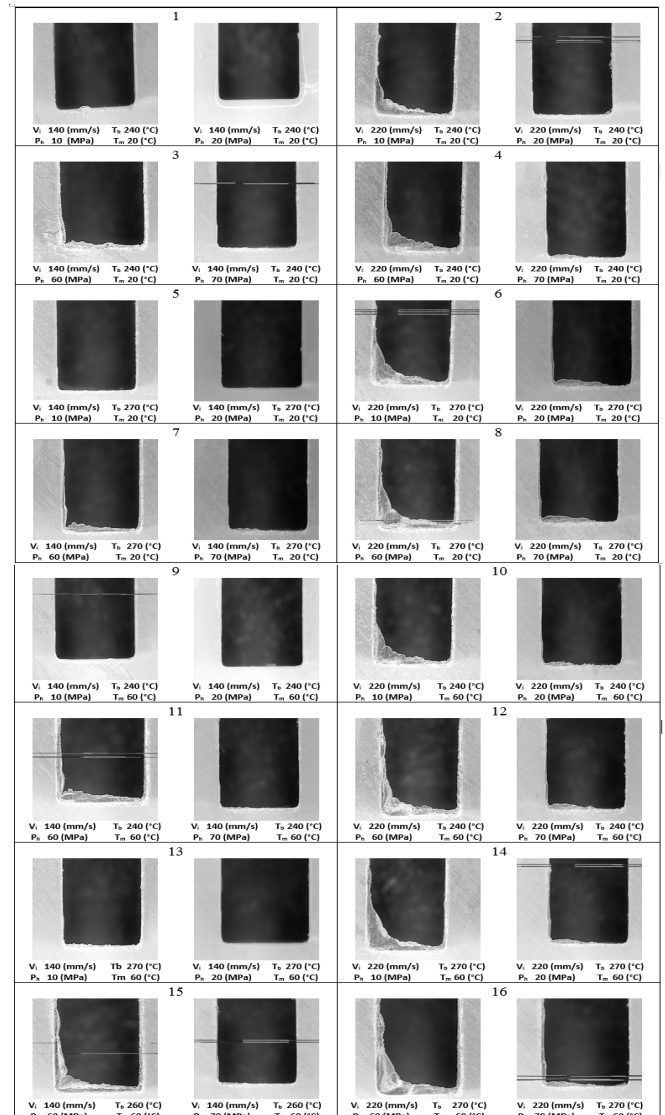


Fig 2: Images of PP (left) and ABS (right) flash formation in different process conditions at all the 16 DOE treatments.

Results and discussion

A fixed position on the molded parts was selected for flash amount comparison. An optical quality control CNC measuring machine was used to take microscopic photographs for evaluating the flash amount formation in corresponding positions of moulded parts for each experimental run for both materials PP and ABS see Figure 2. For the first comparison we can see that the amount of flash formation for PP material is higher than ABS material for all the corresponding 16 DOE treatments leading due to the difference on viscosity where the PP is a material having a low viscosity, which is better for filling the micro features but on the other hand it favours for flash creating.

Conclusion

This paper investigate the effect of four processing parameters injection velocity V_i , holding pressure P_h , melt temperature T_b and mould temperature T_m using flash amount as an experiment output response. Polypropylene (PP) and Acrylonitrile Butadiene Styrene (ABS) grade were used for the injection moulding process. The DoE approach has been applied to assess the effects of the selected four parameters, varying between a maximum and a minimum value. Experimental results and statistical analysis showed that the flash amount created when moulding the PP material is larger than the flash amount for the ABS material. For the PP material, the injection velocity followed by melt temperature are the most influential parameters on the flash amount formation. However, the melt temperature followed by injection velocity are the most influential parameters effect on the flash amount in ABS material moulding. In conclusion, in order to replicate high quality parts, the correct adjustment of the process parameters is crucial. In particular, an increase in injection velocity and melt temperature showed an increase in flash, choice of polymer also had a high effect on both the accuracy of the part and flash formation.

Reference

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Acknowledgement

The authors would like to acknowledge the support from Department of Mechanical Engineering, Technical University of Denmark, Denmark and Egyptian cultural affairs & mission sector, Egypt.